Italian Botanist 18: 123–140 (2024)
doi: 10.3897/italianbotanist.18.132924
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

New data on the morphology, ecology and distribution of *Lupinus gredensis* (Fabaceae) in the Mediterranean region

Salvatore Cambria[1], Cristina Blandino[1], Antonia Cristaudo[1]

1 *Department of Biological, Geological and Environmental Sciences, University of Catania, Via Empedocle 58/ Via A. Longo 19, 95125 Catania, Italy*

Corresponding author: Cristina Blandino (cristinablandino85@gmail.com)

Academic editor: Lorenzo Peruzzi | Received 23 July 2024 | Accepted 22 September 2024 | Published 28 November 2024

Citation: Cambria S, Blandino C, Cristaudo A (2024) New data on the morphology, ecology and distribution of *Lupinus gredensis* (Fabaceae) in the Mediterranean region. Italian Botanist 18: 123–140. https://doi.org/10.3897/italianbotanist.18.132924

Abstract

Lupinus gredensis is generally treated as an endemic species to the Iberian Peninsula, with some occurrences reported for the eastern Mediterranean, considered to be the result of an introduction. The finding of five populations attributable to *L. gredensis* on the south-eastern slopes of Mt. Etna (Sicily, Italy) is here reported for the first time. *Lupinus gredensis* samples from Mt. Etna were morphologically compared with fresh and herbarium preserved specimens of the related species *L. luteus* and *L. hispanicus*. The distribution and the ecology of the surveyed populations, as well as the phytosociological characterization of the plant communities hosting *L. gredensis* are defined. Finally, the chorological status of this species in Sicily is discussed through the review of the historical occurrence of *L. luteus* in the Mt. Etna area, providing new data on the putative distribution range of *L. gredensis* in the Mediterranean region.

Keywords

Italy, microstructure of seed coat, plant community, Sicily, vascular flora

Introduction

According to Pignatti et al. (2017) and Bartolucci et al. (2024), the genus *Lupinus* L. in Italy is represented by five native taxa: *L. albus* L. subsp. *graecus* (Boiss. & Spruner) Franco & P.Silva, *L. angustifolius* L., *L. cosentinii* Guss., *L. gussoneanus* J.Agardh and

Copyright *Salvatore Cambria et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

L. luteus L. Moreover, Galasso et al. (2024) reported *L. albus* subsp. *albus* and *L. polyphyllus* Lindl. as naturalized species. Except for the North American *L. polyphyllus*, all the other species mentioned for Italy are also present in Sicily (Giardina et al. 2007). The discovery of some populations on the eastern slope of Mt. Etna (E Sicily) not identifiable with any taxon known for the island, and the critical review of the herbarium specimens have made it possible to report for the first time the occurrence of *L. gredensis* Gand. in Italy. This taxon, first described by Gandoger (1901), was later treated as a variety or subspecies of the closely related *L. hispanicus* Boiss. & Reut. by some authors (Merino 1905; Gladstones 1974). More recently, it was re-evaluated to the rank of species due to the significant morphological differences between the two taxa, which mainly regard the flower color: lilac to violet in *L. hispanicus* and cream-pale yellow in *L. gredensis*, in which the lower whorls turn lilac to mauve at the end of the anthesis (Castroviejo and Pascual 1998, 2000). According to many sources (Castroviejo and Pascual 2000; Euro+Med 2024; POWO 2024), *L. gredensis* is endemic to the western and central areas of the Iberian Peninsula. However, this species has been reported as introduced into Greece, Turkey, and Bulgaria (Dimopoulos et al. 2013; Stoyanov and Apostolova-Stoyanova 2022). As concerns the Turkish (W Anatolia) and the Greek (NE Greece and east Aegean Islands) populations, the status of *L. gredensis* as an alien species is particularly controversial. Strid (2016, 2024) stated this the species occurs in natural environments and behaves like a native plant, suggesting a disjunct distribution in the Western (Spain and Portugal) and Eastern Mediterranean (NE Greece, NE Aegean area, and W Anatolia). As reported by Stoyanov and Apostolova-Stoyanova (2022), this statement could also be supported by the occurrence of a specimen (SOA 10227), which demonstrates its presence in Greece for at least a century, as well as by the record of *L. hispanicus* from Greece by Hayek (1927). The earliest specimen of *L. gredensis* (under the name *L. hispanicus*) in Turkey dates back to 1966 and is cited in Chamberlain (1970). Unfortunately, there are no data in the literature regarding the introduction of this species into cultivation, also because until its revaluation (Castroviejo and Pascual 1998) *L. gredensis* was not considered as a species distinct from *L. hispanicus*. Actually, *L. gredensis* is occasionally used, mainly in the Iberian Peninsula, as an alternative leguminous crop for marginal areas (Lema and Soengas 2023). Regarding the occurrence of *L. gredensis* in Bulgaria, Stoyanov and Apostolova-Stoyanova (2022) hypothesized that it has been imported as an ornamental plant or casually, by transportation of cereals and soil mixtures. However, they consider more probable its spreading from the adjacent territories in the Greek Rhodope. In this paper, the chorological status of *L. gredensis* in Sicily is discussed through ecological considerations and the study of historical herbarium specimens. Moreover, the description of some morphological traits of the surveyed populations, the phytosociological characterization of the Sicilian *L. gredensis* community, and its distribution in Sicily are provided.

Materials and methods

Field surveys and distribution data

We conducted field surveys in Sicily (Aeolian Islands, Nebrodi mountains, Peloritani mountains and Mt. Etna) from 2022 to 2024. Flowering and fruiting specimens of *L. gredensis* were collected in the south-eastern side of Etna volcano from five localities during spring 2024 (April to June). The collected specimens have been deposited in the CAT herbarium (the herbarium acronym follows Thiers 2024).

Additional information on the distribution of *L. gredensis* in Sicily were obtained from plant photographs published online by the members of the Facebook group "Flora spontanea Siciliana" (www.facebook.com/groups/floraspontaneasiciliana/) and from private photographic archives (R. Galesi and G. Siracusa pers. comm.).

Morphological investigations

Morphological observations were made on ten fresh individuals for each of the five populations of *L. gredensis* reported for Sicily. The specimina visa from these populations were compared with data from protologue and relevant literature (Merino 1895, Gandoger 1901, Castroviejo and Pascual 2000). In particular, the Sicilian specimens labeled as *L. luteus*, collected on Mt. Etna and stored in CAT and PAL herbaria, were examined to define their correct taxonomical attribution. Moreover, GBIF (Global Biodiversity Information Facility database, https://www.gbif.org/) records of *L. gredensis* from Portugal, Spain, Greece, and Turkey were examined. The comparison with the most similar species (*L. luteus* and *L. hispanicus*) was carried out using both fresh samples and scanned herbarium specimens preserved in ABH, CAT, GJO, PAL, PI, W, WAG. In particular, the three species have been differentiated on the basis of the following characters: stem indumentum, leaf upper surface, leaf stipules, corolla color, number of whorls in the inflorescences, and pod morphology (surface hairiness, position and beak).

Ten dry mature seeds of *L. gredensis* belonging to four different specimens from Mt. Etna, ten seeds of *L. luteus* belonging to five different specimens from Stromboli (Aeolian Islands) and two seeds obtained from the herbarium specimen CAT005493, were photographed using a scanning electron microscope (SEM) at an accelerating voltage of 10 kV. Specifically, Phenom XL G2 Desktop SEM was used. Seeds were directly mounted on to aluminium stubs with double adhesive tape and then sputter coated with gold. The images obtained where then analyzed using the software ImageJ, version 1.54 (Abramoff et al., 2004) to measure the perimeter and the area of 20 randomly selected palisade cells. The results were statistically compared with Student's t-test, using software R, version 4.2.2 (R Core Team, 2022). No cells were measured from the two seeds sampled from the specimen CAT005493.

Phytosociological survey

Vegetation relevés were sampled in the patches with high cover of *L. gredensis*, according to Braun-Blanquet's methodology (Braun-Blanquet 1928). The phytosociological nomenclature mainly refers to Mucina et al. (2016) and the bioclimatological classification follows Bazan et al. (2015).

Specimina visa

Lupinus gredensis

Italy, Sicily. Etna, s.d., *Todaro s.n.* (PAL144! sub *Lupinus luteus*); *ibid.* (PAL145!); Etna, Tarderia, 9 May 1829, *Tineo s.n.* (PAL146! sub *Lupinus luteus*); Zafferana, May 1888, *Tornabene s.n.* (CAT005482! sub *Lupinus thermis*); *ibid.* (CAT005483!); *ibid.* (CAT005484!); *ibid.* (CAT005485!); *ibid.* (CAT005486!); *ibid.* (CAT005487 Milo, April 1894, *P. Baccarini s.n.* (CAT005498! sub *Lupinus luteus*); Etna, Aironi, July 1894, *P. Baccarini s.n.* (CAT005496! sub *Lupinus luteus*); Etna, Valle di Calanna, 11 June 1903, *Cavara s.n.* (CAT005493! sub *Lupinus luteus*);, Valle di Calanna, Acqua Grande, 11 June 1903, *Cavara s.n.* (CAT005495! sub *Lupinus luteus*); Etna, Valle Calanna, 12 June 1903, *Cavara s.n.* (CAT005492! sub *Lupinus luteus*); Etna, Randazzo, 10 May 1913, *S. Tricomi s.n.* (CAT005495! sub *Lupinus luteus*); Etna, Pedemontana, 21 May 1989, *A. Cristaudo s.n.* (CAT112411! sub *Lupinus luteus*); Contrada Faro, Tarderia (Pedara), 37°39'20.3"N, 15°02'14.8"E, 990 m, 4 May 2024, *A. Cristaudo & S. Cambria s.n.* (CAT!); Contrada Monte Gorna-Grottafumata, Trecastagni (Etna), 37°39'04.7"N, 15°04'26.4"E, 750 m, 4 May 2024, *A. Cristaudo & S. Cambria s.n.* (CAT!); Nei pressi della grotta del Gatto, Zafferana Etnea (Etna), 37°40'53.67"N, 15°05'5.92"E, 930 m, 4 May 2024, *A. Cristaudo & S. Cambria s.n.* (CAT!); Monte Gervati, Nicolosi (Etna), 37°38'34"N, 15°01'18.6"E, 950 m, 4 May 2024, *A. Cristaudo & S. Cambria s.n.* (CAT!); Monte Serra Pizzuta, Nicolosi (Etna), 37°38'34.46"N, 15°1'11.34"E, 37°38'33.04"N, 15°1'8.32"E, 940 m, 4 May 2024, *A. Cristaudo & S. Cambria s.n.* (CAT!).

Lupinus luteus

Italy: Sicilia, s.d., s.c. (WAG0253257!); Italia, Calabria, Reggio, s.d., s.c. (PAL!); Italia, Sicilia, Isole Eolie, Costa del Cappero – Lipari (ME), 13 April 1877, *Lojacono Pojero s.n.* (PAL!); Sicilia. Messana (Messina), in aridis collium prope Gravitelli, alt. 200 m., suolo siliceo, April 1906, *G. Zodda s.n.* (PI044744!); Italia, Sicilia, Isole Eolie, Vulcanello (ME), 8 May 1995, *A. Carratello s.n.* (PAL!); Italia, Sicilia, Madonna di Trapani, Messina, 200 m, 16 April 2008, *R. Galesi s.n.* (CAT!); Italien, Calabria: Aspromonte Provincia Reggio di Calabria, Comune San Lorenzo; etwa 14 km N Marina di San Lorenzo und 3 km NE Bagaladi; an einem südlichen Hang vom Monte Perpoli, um den Weiler San Antonio; 38°02'24.3"N, 15°51'05.1"E ±100 m, 920 m, 3 May 2014, *K. Zernig 8773* (GJO!); Stromboli, (Aeolian Island), 256 m, 16 June 2014, *A. Cristaudo & S. Catara s.n.* (CAT!).

Lupinus hispanicus

Spain: Alájar, Sª de Aracena, subida a la ermita Virgen de los Angeles, 9 April 2004, *M. Martinez Azorin s.n.* (ABH50296!); Spain, Andalucía, prov. de Córdoba, road Adamuz to Obejo c. 11 km NW of Adamuz, bridge over río Varas, along river, 38°04'53"N, 04°37'58"W, 225 m, 23 April 2016, *P. Escobar-Garcia & E. Vitek s.n.* (W00894!); España, [Castilla y León,] Ávila, Navatalgordo, 40°24'30.69"N, 4°52'46.79"W, 22 May 2016, *P. Escobar-Garcia s.n.* (W03181!).

Results

Morphological and taxonomical considerations

Lupinus gredensis, together with *L. luteus* and *L. hispanicus*, forms a well-supported taxonomic complex from a morphological and cytological point of view within the genus *Lupinus* L. (Castroviejo and Pascual 1998, 2000; Naganowska and Ladoň 2000). According to Euro+Med (2024), these three species are widespread in the Iberian Peninsula, while their presence in other Mediterranean territories may be considered as the result of an introduction although, according to numerous other sources (Pignatti 2017; POWO 2024), at least *L. luteus* can be considered native to the Italian Peninsula, Sardinia and Sicily.

The morphological study of the five populations found in Sicily has allowed a certain attribution of the material investigated to *L. gredensis* (Fig. 1). This taxon is easily distinguishable from all the other species known for Italy by the color of the corolla. The only native species that shows some affinity with it is *L. luteus* L. that, however, always has flowers with an intense yellow corolla and densely hairy leaves on both blades. *Lupinus gredensis* clearly differs from *L. luteus* for other morphological characters, such as: leaves glabrous on the upper blade or with hairs only on the margin; inflorescence generally with less than 11 whorls; flower peduncles longer than 2 mm; ripe pod yellowish-brown (vs dark brown), almost erect before maturation, with 5–7 (vs 4–5) seeds, often adorned with a colored arch towards the hilum. Finally, the leaf stipules, in *L. luteus*, are dimorphic: linear in the basal leaves and foliaceous in the upper ones. The flowers of *L. hispanicus*, are lilac to violet throughout flowering; it has appressed-hairy stem, shorter inflorescence with 3–7 whorls and tuberculated seeds (Boissier and Reuter 1842; Castroviejo and Pascual 1998, 2000). The main diacritical characters of these three species are listed in Table 1 and illustrated in Fig. 2.

Here we give provide a description of the Sicilian plants, which agrees with Castroviejo and Pascual (2000):

Annual herb 15–80 cm tall, from villous-hairy to hairy. Stem generally branched from the base, with prostrate-ascending stems. Leaves with petiole 9.7–12.1 cm long, divided into 5–9 leaflets of 20–72.2 × 6.9–18.3 mm, mucronulate in the lower leaves, oblanceolate in the upper ones, glabrous or slightly hairy at the margin in the upper blade, appressed hairy in the lower one; stipules linear, 9.5–15.7 mm long with membra-

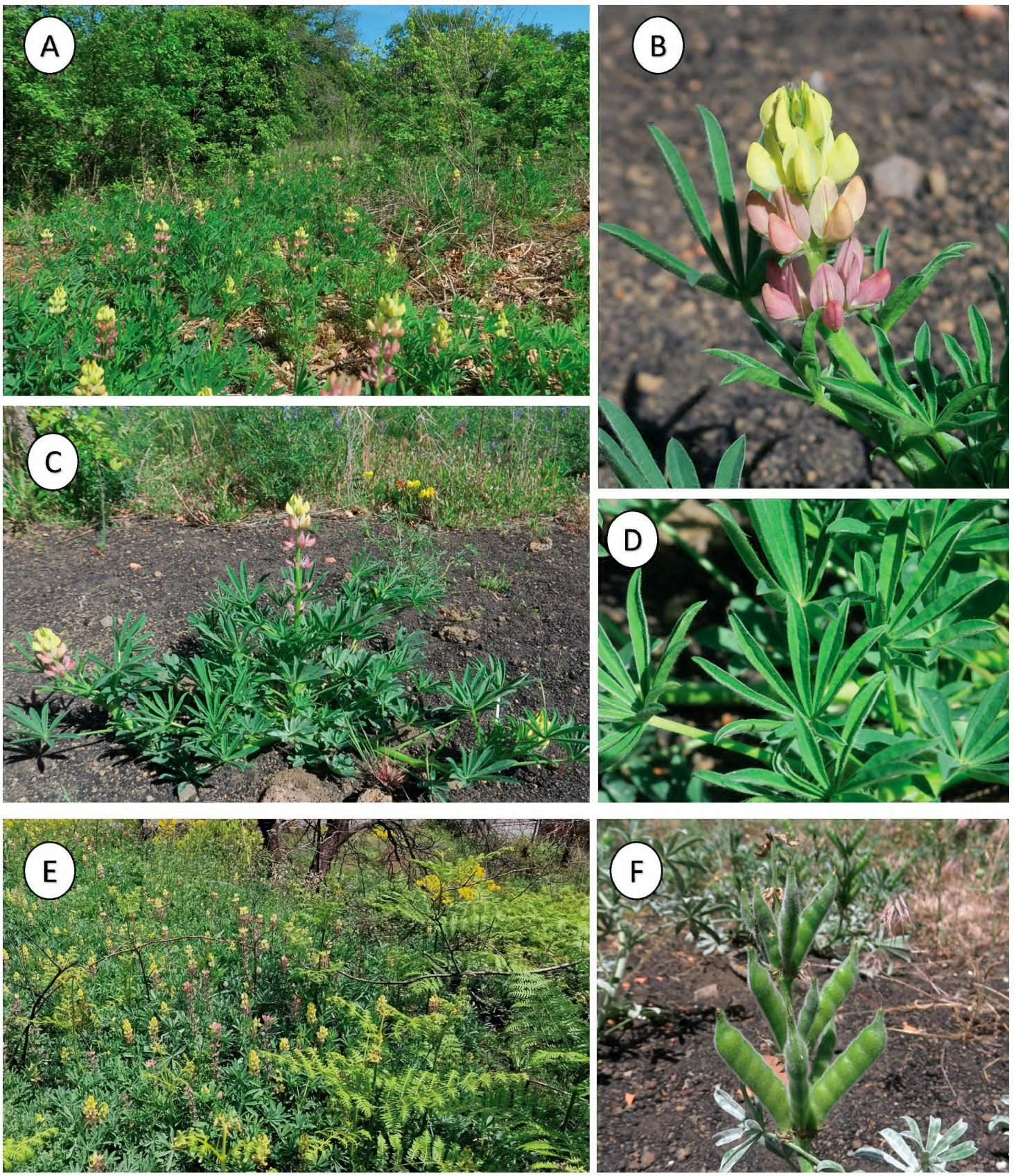

Figure 1. *Lupinus gredensis* in Sicily **A** habitat in wood clearings **B** detail of inflorescence **C** habitus **D** leaf blade **E** *L. gredensis* in the undergrowth of vegetation with *Pteridium aquilinum* **F** immature pods. In **F** the whitish colour of the leaves is due to a fungal infection.

nous margin. Inflorescence 7.5–26.1 cm long, constituted by 5–10 whorls of 5 flowers each; pedicels 1.8–2.7 mm long; bracts ovate-oblong, sharp, deciduous; bracteoles linear. Calyx bilabiate, with appressed to sub-patent sericeous hairs; upper lip fissured almost to the base, 5.9–7.3 mm long; lower lip tridentate, 7.3–9.3 mm long. Corolla pale yellow in the upper 3–4 whorls, pink or lilac in the central and lower whorls. Standard 14.2–18.4 × 8–11.1 mm; wings 15.5–17 × 7.3–9 mm; keel 12.6–14.7 × 3.8–4.8 mm. Ferruginous-brown, patent-hairy legume, up to 65 mm long and up to 11 mm wide,

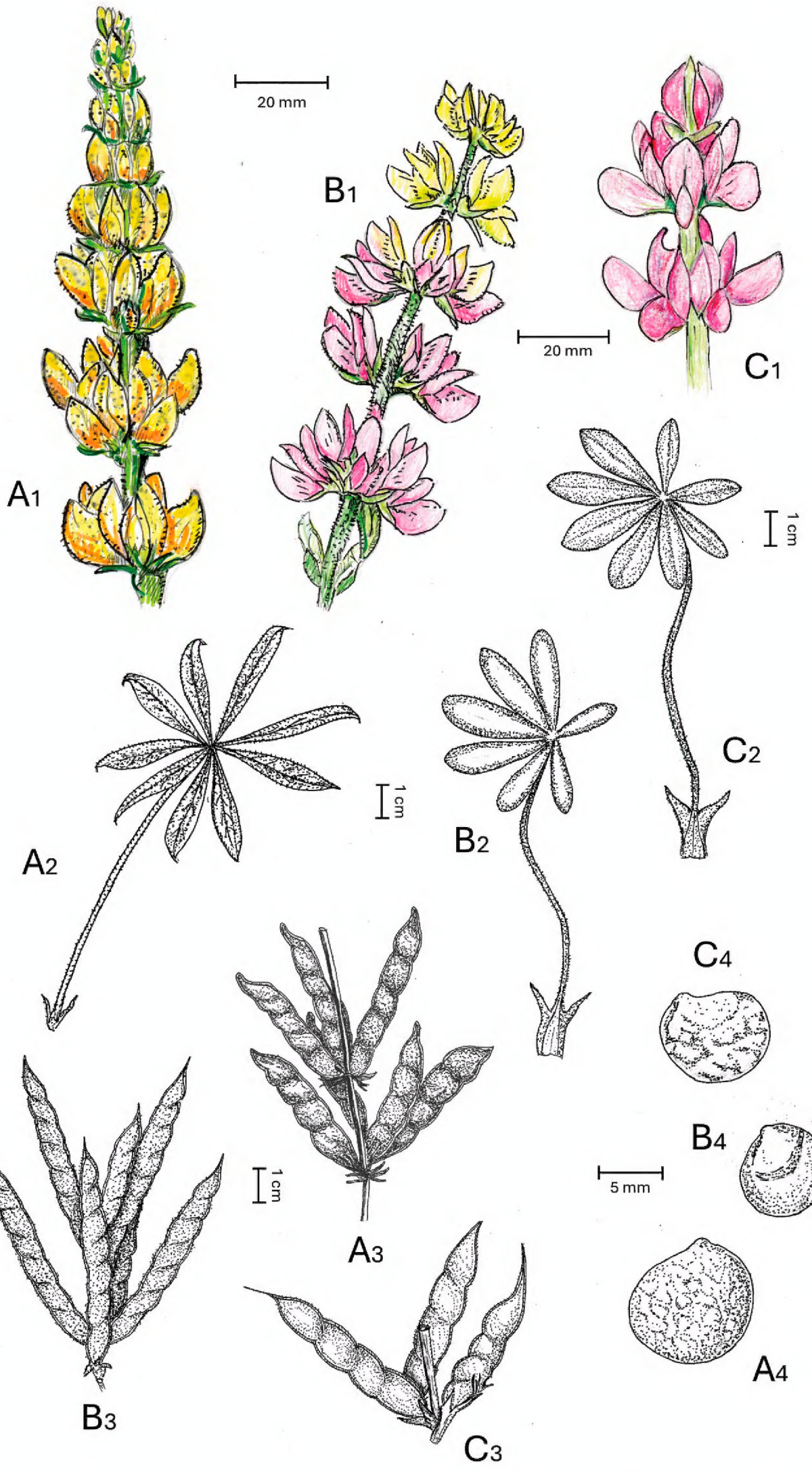

Figure 2. Illustration of *Lupinus gredensis* and of the related species *L. luteus* and *L. hispanicus. L. gredensis* (**A**), *L. luteus* (**B**) and *L. hispanicus* (**C**). 1. Inflorescence. 2. Leaves. 3. Pod. 4. Seed. Drawings by Rosaria Di Cicca.

Table 1. Main morphological diacritical characters of *Lupinus gredensis*, *L. hispanicus* and *L. luteus*.

Character	*L. gredensis*	*L. hispanicus*	*L. luteus*
Stem indumentum	sparsely hairy	appressed-hairy	sericeous
Leaves upper blade	glabrous with hairs on the margin	glabrous or sparsely hairy	hairy
Leaf stipules	linear	linear	linear or foliaceous
Corolla color	cream, lilac to mauve in the lower whorls	lilac to violet	yellow
Number of whorls	5–10	3–7	6–12
Pod surface	sericeous, yellowish-brown	sericeous, yellowish-brown	densely hairy, dark brown
Pod shape	almost erect before maturation	slightly divaricate	horizontal or divaricate
Pod beak	erect-patent	erecto-patent	curved
Seeds per pod	5–7	(3)4–5	4–5
Seed surface	smooth with a colored arch near the hilum	tubercolated	smooth with a darker layer above a white bottom

almost erect before maturation, ending with a sharp, erect-patent beak of 8–10 mm, with 5–7 seeds. Seeds 4.6–6.2 mm in diameter, lenticular to globose-lenticular, generally white with a colored arch near the hilum and a smooth head.

According to various authors (Heyn and Herrnstadt 1977; Aïnouche and Bayer 2000; Aïnouche et al. 2004; Marzouk 2006), the microstructure of the seed coat and the unicellular pattern of microsculptures represent significant taxonomical characters in the genus *Lupinus*, which allow distinguishing the different taxa. The micromorphological investigation of seed coat (Fig. 3) of *L. gredensis* revealed a smooth surface with very cohesive and prominent isodiametric palisade cells (macrosclereids). The outer periclinal wall of these cells is characterized by irregular microsculptures with curved tips, while the anticlinal walls look from slightly curved to straight. As concerns *L. luteus*, previously examined by Mahé (2011), the cells are significantly ($p < 0.005$) greater (area = 143.13 $\mu m^2 \pm$ 6.29 SE; perimeter = 47.43 $\mu m \pm$ 1.06 SE) and with a surface more prominently sculptured if compared to *L. gredensis* (area = 32.00 $\mu m^2 \pm$ 1.72 SE; perimeter = 22.13 $\mu m \pm$ 0.69 SE). Besides, *L. luteus* shows a different micromorphological pattern, as well as less marked and quite obscure anticlinal walls. Although it was not possible to take precise measurements on the seeds sampled from the herbarium specimen CAT005493, the microstructure patterns of the periclinal walls and the cell size are more similar to those of *L. gredensis* rather than *L. luteus*. However, both *L. luteus* and *L. gredensis* fully belong to the group of smooth seeded lupins for the cohesive and isodiametric external palisade cells.

Analitycal key to species of the genus *Lupinus* in Italy

An analytical key for recognizing the various taxa belonging to the *Lupinus* genus in Italy is shown below.

1 Corolla yellow or yellowish; flowers clearly arranged in regular whorls **2**
– Corolla white or blue; flowers arranged in raceme or irregular whorls **3**

2 Flowers always with bright yellow corolla; leaves hairy on both blades; pod always horizontal or divaricate ..... ***L. luteus***
– Flowers pale yellow at the beginning, progressively turning pink or mauve with ripening; leaves hairy only on the lower blade; pod almost erect before maturation ..... ***L. gredensis***
3 Flowers clustered in false whorls or irregular whorls; leaves hairy on both blades **4**
– Flowers scattered along the axis of the inflorescence; leaves hairy only in the lower blade **5**
4 Lower flowers not whorled, corolla 10–14 mm long; calyx with trifid lower lip; seeds smooth ..... ***L. gussoneanus***
– Lower flowers whorled, corolla 15–17 mm long; calyx with bifid lower lip; seeds rough ..... ***L. cosentinii***
5 Upper lip of calyx subentire or with slightly marked teeth; leaves with wide oblong-obovate to oblanceolate leaflets **6**
– Upper lip of calyx deeply bifid; leaves with narrow and linear leaflets ..... ***L. angustifolius***
6 Perennial plant; leaves with 11–15 leaflets of (4)7–15 × 1.5–3 cm ..... ***L. polyphyllus***
– Annual plant; leaves with 5–9 leaflets of 2–8 × 0.5–2 cm 7
7 Flowers with white corolla ..... ***L. albus* subsp. *albus***
– Flowers with blue corolla ..... ***L. albus* subsp. *graecus***

Distribution and ecology of *L. gredensis* in Sicily

Field investigations allowed to ascertain the occurrence of at least five populations, all located on the south-eastern side of Mt. Etna and precisely in the territories of Trecastagni, Nicolosi, Pedara, and Zafferana Etnea. However, based on the analysis of photographic material published online (www.facebook.com/groups/floraspontanea-siciliana/) or stored in private photographic archives (R. Galesi and G. Siracusa pers. comm.) and kindly made available, it can be assumed that this species is also present in other areas, often in localities adjacent to those known to us (Fig. 4). Further data on the distribution of this species were provided by the review of herbarium specimens labeled as *L. luteus* which, as far as the Mt. Etna area is concerned, are often referable to *L. gredensis*. The locations reported in the oldest specimens, although often not very precise, are largely comparable with those detected by field investigations. The only locality quite distant from the other populations is located in the surroundings of Randazzo (northern side of Etna), as recorded by a specimen collected by S. Tricomi in 1913 (CAT005495) and another in 1989 (CAT112411).

In Sicily, *L. gredensis* grows only on volcanic sands at altitudes between 700 and 1,100 m a.s.l., colonizing clearings of deciduous or holm oak forests, roadsides and uncultivated lands. As highlighted by Milla et al. (2011), *L. gredensis* shows lower fitness and a competitive disadvantage compared to *L. angustifolius*, widespread in the same environments, being much less abundant than the latter. *Lupinus gredensis* is able

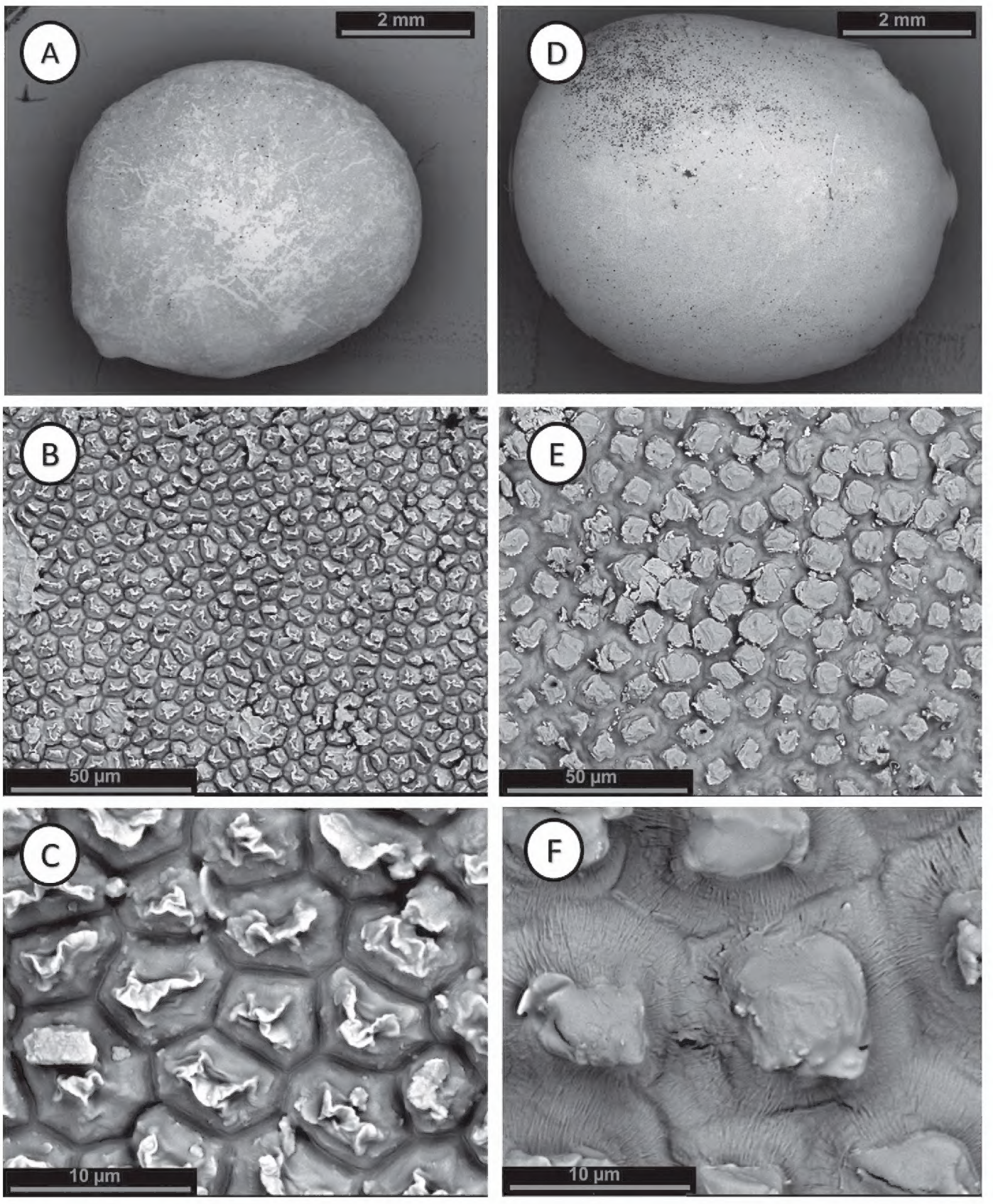

Figure 3. SEM micrographs of seed. *Lupinus gredensis*: **A** whole seed view (× 37) **B** seed coat view (× 2900) **C** detail of seed coat (× 14000). *Lupinus luteus*: **D** whole seed view (× 37) **E** seed coat view (× 2900) **F** detail of seed coat (× 14000).

to form denser populations only in the presence of substrates characterized by highly incoherent and poorly developed soils with a very fine texture, where competition with *L. angustifolius* and other ruderal species is less marked. Overall, the observed ecological preferences coincide with those reported by Castroviejo and Pascual (2000) and by Costa et al. (2012) in the Iberian Peninsula. In fact, according to these authors, *L. gredensis* colonizes abandoned crops, grasslands and degraded scrubs in siliceous or de-

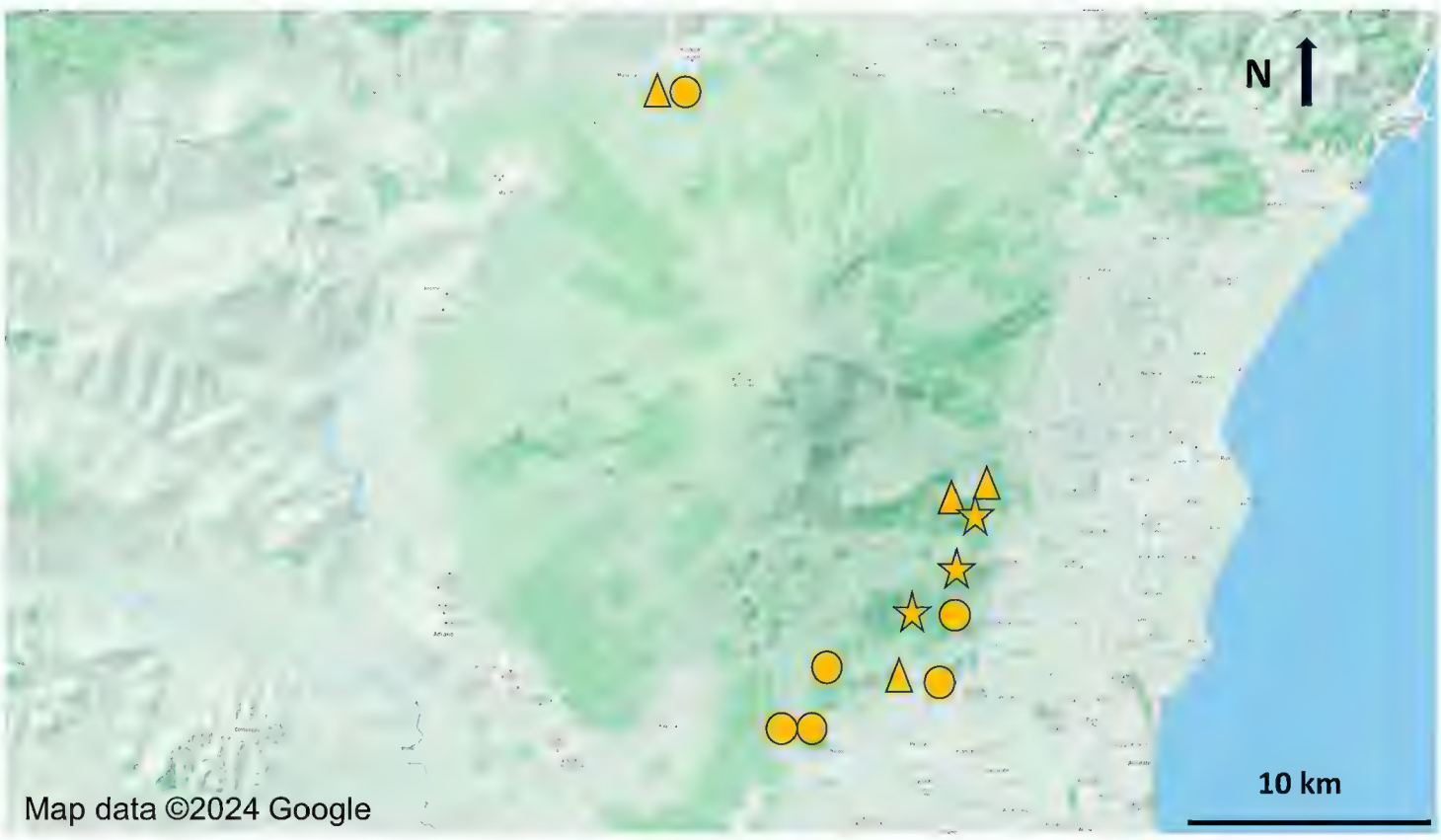

Figure 4. Distribution of *Lupinus gredensis* on Mt. Etna (Sicily). Data obtained from field investigations (circles); herbarium specimens (triangles); photographic documentations (stars).

carbonated soils up to 1,500 m a.s.l. As regards the Bulgarian populations, they occur mainly on ruderal habitats on siliceous substrates up to 700 m, along roadsides and uncultivated lands (Stoyanov and Apostolova-Stoyonova 2022).

Distribution and ecology of *L. luteus* in Sicily

According to field and herbarium investigations, the occurrence of *L. luteus* in Sicily is confirmed in numerous other areas of the island, such as on the Peloritani and Nebrodi mountains, western Sicily (Ficuzza and Alcamo), the Aeolian islands, and Pantelleria (Giardina et al. 2007). On Mt. Etna, its occurrence can be confirmed only in the basal thermo-Mediterranean belt of the eastern side between 100 and 350 m, as resulting from our observations and from the literature (Musmeci 2024). From the ecological point of view, this species is linked to dry meadows on siliceous soils (mainly quartzarenites, metamorphites and vulcanites) from sea level to 600 m a.s.l.

Phytosociological remarks

This species has been found in various plant communities, although it is mainly linked to aspects of ruderal vegetation attributable to the class Chenopodietea Br.-Bl. in Br.-Bl. et al. 1952. In particular, *L. gredensis* sometimes colonizes the clearings and edges of mesophilous woods belonging to the class *Quercetea ilicis* Br.-Bl. ex Molinier 1934 or is represented in sub-nitrophilous communities characterized by *Pteridium aquilinum* (L.) Kuhn, linked to stations with deep and fertile soils (Brullo and Marcenò

1985). However, the most characteristic populations of *L. gredensis* can be referred to a ruderal community linked to siliceous sandy soils (Table 2), belonging to the order *Brometalia rubenti-tectorum* (Rivas Goday & Rivas-Mart., 1973) Rivas-Mart. & Izco, 1977. Due to its ecological and floristic peculiarities, we consider appropriate to describe a new association, namely *Linario aetnensis-Lupinetum gredensis* Cristaudo & Cambria, ass. nov. (holotypus: Table 2, rel. 2, hoc loco). This association, fairly poor from a floristic point of view, is clearly dominated by *L. gredensis* accompanied by few other species with low coverage, such as *Linaria multicaulis* (L.) Mill. subsp. *aetnensis* Giardina & Zizza, *Lupinus angustifolius*, *Anisantha tectorum* (L.) Nevski, *Isatis tinctoria* L. subsp. *canescens* (DC.) Arcang. Overall, this community shows a pioneer character in the colonization of coarse sandy soils and is found mainly in uncultivated and large woodland clearings. From a bioclimatic point of view, this vegetation belongs to the meso-Mediterranean belt with a humid ombrotype.

Discussion and conclusions

Based on herbarium investigations, the occurrence of *L. gredensis* in Sicily and Italy, although reported here for the first time, cannot be considered as the result of a recent introduction. In fact, our investigations reveal that it had previously been confused by numerous authors with *L. luteus*, a rather sporadic taxon on the island, found mainly in NE Sicily and on some small islands, but which seems to be missing from the meso-Mediterranean belt of Mt. Etna. In fact, all the examined samples of *L. luteus* coming from altitudes above 500–600 m in the Mt. Etna area, must be attributed to *L. gredensis* based on the morphology of their leaves, inflorescences, and pods. The SEM observations of the seed coat coming from the herbarium specimen CAT005493, collected by Cavara (1904) and attributed to *L. luteus*, provides further support for its correct attribution to *L. gredensis*.

Furthermore, all the historical localities of the examined Etnean specimens, tentatively referred to *L. luteus*, coincide with those in which *L. gredensis* was found in the present study. However, *L. luteus* was not found on Mt. Etna during field surveys, except for a few localities at very low altitudes according to its thermophilous requirements. The first mention of *L. luteus* on Mt. Etna dates to Rafinesque-Schmaltz (1815), subsequently also reported by Strobl (1880), who however did not collect any samples. On the contrary, Tornabene (1889–1892) does not report this taxon for Mt. Etna, citing instead *Lupinus termis* Forssk. Later, Cavara (1904) claims that the samples labeled as *L. termis*, from the Tornabene herbarium (CAT) and collected in Zafferana Etnea (Fig. 5), should be referred instead to *L. luteus*, while in our opinion they should be attributed to *L. gredensis*. The presence of *L. luteus* on Mt. Etna is also reported generically by Lojacono (1891) and, more recently, by Sciandrello et al. (2020). Further information was provided by Cavara (1904) who considered *L. luteus* to be an infrequent but fairly widespread species on the eastern side of the volcano, even in natural environments (such as Valle Calanna, at an altitude of 900–1000 m), denying the possibility of its introduction by man.

Table 2. Phytosociological relevés of the plant community with *Lupinus gredensis* on Etna. Relevés 1 and 2 were made in Monte Gorna-Grottafumata, Trecastagni (CT, Italy), on 4th May 2024; relevés 3 and 4 were made in Monte Gervati, Nicolosi (CT, Italy) on 4th May 2024.

***Linario aetnensis-Lupinetum gredensis* ass. nov.**				
Releves	1	2	3	4
Surface (mq)	90	90	90	90
Altitude	750	750	950	950
Char. Ass.				
Lupinus gredensis	4	4	3	4
Linaria multicaulis subsp. *aetnensis*	1	+	1	1
Char. *Echio Plantaginei-Galactition tomentosae*				
Isatis tinctoria subsp. *canescens*	+	+	+	+
Lotus ornithopodioides	1	.	1	1
Hypochaeris achyrophorus	+	.	.	.
Medicago murex	.	+	.	.
Char. *Brometalia rubenti-tectorum* and Chenopodietea				
Lupinus angustifolius	2	1	+	+
Vicia pseudocracca	+	+	1	+
Anisantha tectorum	1	1	.	+
Anisantha diandra	+	+	.	+
Avena barbata	+	+	.	+
Vicia villosa	+	.	.	1
Erodium cicutarium	+	+	.	.
Lathyrus sphaericus	+	+	.	.
Fumaria officinalis	+	.	.	.
Brassica fruticulosa	.	.	+	.
Geranium molle	+	.	.	.
Other species				
Ornithopus compressus	1	1	+	+
Hypochoeris radicata	+	+	+	+
Festuca myuros	+	+	+	.
Anchusella cretica	+	+	.	+
Oenothera odorata	1	+	.	.
Scleranthus annuus	+	+	.	.
Thapsia garganica	.	.	1	1
Scrophularia canina	.	.	2	1
Silene conica	+	+	.	.
Rumex multifidus	.	.	+	+
Trifolium incarnatum	+	+	.	.
Centaurea giardinae	.	.	+	+
Aira cupaniana	.	.	+	+
Petrorhagia dubia	.	.	.	+
Rumex bucephalophorus	.	+	.	.
Dactylis glomerata	.	+	.	.
Jacobaea ambigua subsp. *ambigua*	.	.	.	+
Trifolium stellatum	+	.	.	.

The oldest herbarium specimen we have traced dates back to 1825 (PAL146) and was probably collected from Tineo in the Tarderia woodland, a location where *L. gredensis* can currently be found. Therefore, considering the historical data on the presence of *L. gredensis* on Mt. Etna, which clearly deny its recent introduction in

Figure 5. Specimen of *Lupinus gredensis* from the Tornabene herbarium (CAT), dated May 1888 and collected in Zafferana Etnea (Catania, Italy).

Sicily, and the presence of native populations even in natural or semi-natural contexts such as clearings and woodland edges, the native status of this species cannot be completely excluded. However, it may be also the result of an ancient introduction. Given the present state of knowledge, it may be, therefore, correct to define *L. gredensis* as a cryptogenic species for the Sicilian flora. Besides, the presence of this species only above 500 m of altitude highlights its markedly mesophilous character, as emphasized also by Castroviejo and Pascual (1998), who reported its occurrence in the Iberian Peninsula at altitudes up to 1,500 m. From the phytogeographical viewpoint, the presence of *L. gredensis* in Sicily should not be surprising given that, according to Raimondo et al. (2010), the western Mediterranean element represents the 9.75% of all Sicilian flora. In fact, except for *L. hispanicus*, all the native species of the genus *Lupinus* listed in Flora Iberica (Castroviejo and Pascual 2000) are present also in Sicily. If the status of *L. gredensis* as a native species in Sicily is confirmed, its distribution range should be expanded to include the Iberian Peninsula and Sicily (Fig. 6). Further field and herbarium investigations may clarify the possible occurrence of the species in other areas of Sicily and Italy, thus providing more information for defining the distribution range of this taxon. At the same time, additional analyses, including in-depth population genetic studies using SNPs or ribotyping, could disentangle the uncertainties about the native status of *L. gredensis* in Italy.

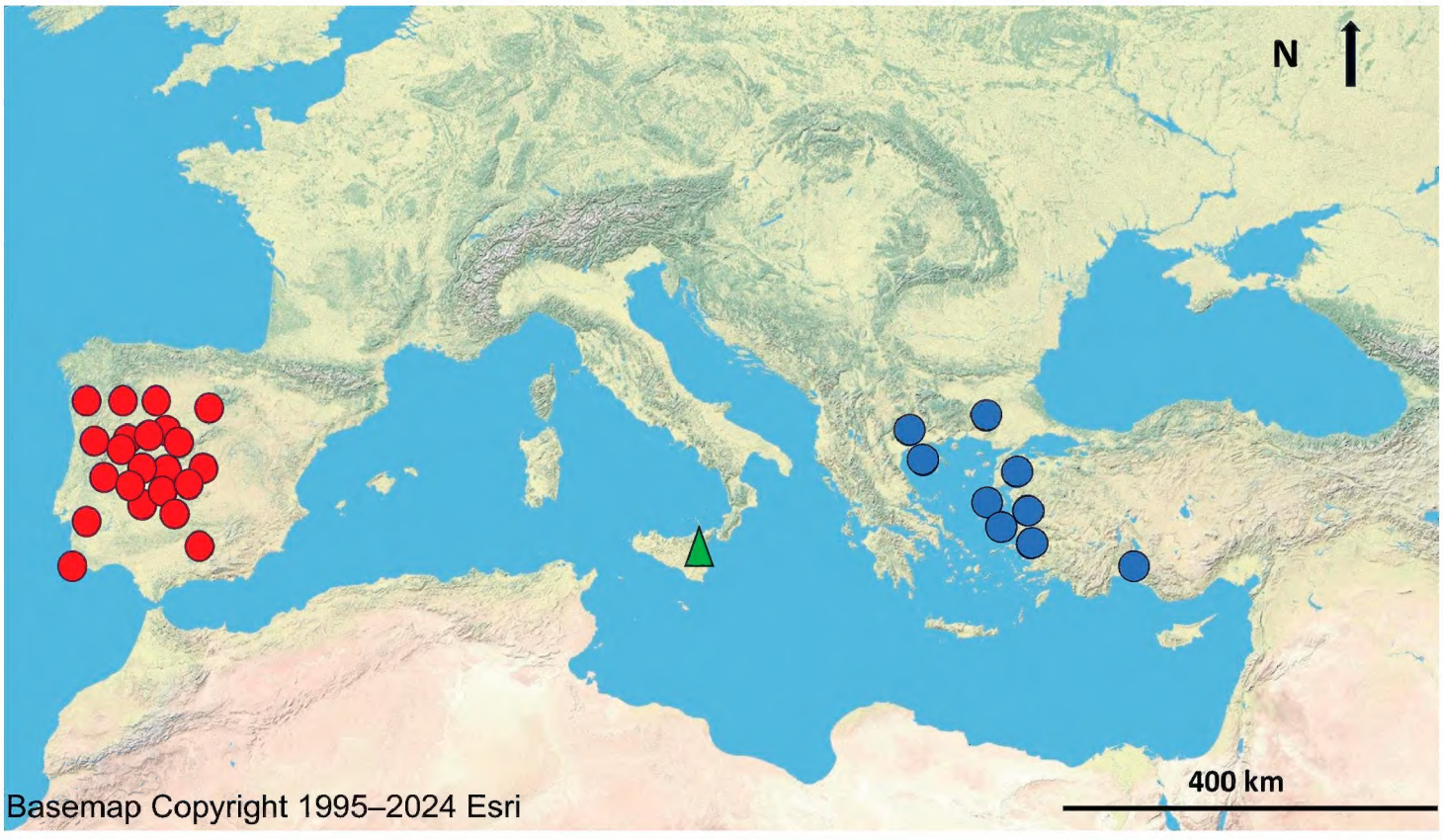

Figure 6. Distribution range of *Lupinus gredensis*. The dots indicate the verified data collected from literature, herbarium specimens and GBIF records (https//:www.gbif.org), the green triangle refers to the specimens collected by the authors on Mt. Etna (Sicily). Presently, is considered as cryptogenic in Sicily. Red dots indicate sites in which the species is considered native, blue dots sites in which the species is considered introduced.

Acknowledgements

The authors are very grateful to Rosario Galesi, Giuseppe Siracusa and Alfredo Carratello, for support in herbarium research, to Diego Leone for his useful collaboration and technical assistance for the SEM surveys and to Rosaria Di Cicca for the drawing of Fig. 2. Finally, we would like to thank Gianniantonio Domina and two anonymous reviewers for their precious advice, which significantly improved the manuscript.

References

Abramoff MD, Magalhaes PJ, Ram SJ (2004) Image Processing with ImageJ. Biophotonics International 11(7): 36–42. https://imagescience.org/meijering/publications/download/bio2004.pdf

Aïnouche A, Bayer RJ (2000) Genetic evidence supports the new Anatolian lupin accession, *Lupinus anatolicus*, as an old world "rough-seeded" lupin (section *Scabrispermae*) related to *L. pilosus*. Folia Geobotanica 35: 83–95. https://doi.org/10.1007/BF02803088

Aïnouche A, Bayer RJ, Misset M (2004) Molecular phylogeny, diversification and character evolution in *Lupinus* (Fabaceae) with special attention to Mediterranean and African lupins. Plant Systematics and Evolution 246: 211–222. https://doi.org/10.1007/s00606-004-0149-8

Bartolucci F, Peruzzi L, Galasso G, Alessandrini A, Ardenghi NMG, Bacchetta G, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Calvia G, Castello M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gottschlichr G, Guarino R, Gubellini L, Hofmann N, Iberite M, Jiménez-Mejías P, Longo D, Marchetti D, Martini F, Masin RR, Medagli P, Peccenini S, Prosser F, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2024) A second update to the checklist of the vascular flora native to Italy. Plant Biosystems 158(2): 219–296. https://doi.org/10.1080/11263504.2024.2320126

Bazan G, Marino P, Guarino R, Domina G, Schicchi R (2015) Bioclimatology and vegetation series in Sicily: A geostatistical approach. Annales Botanici Fennici 52(1–2): 1–18. https://doi.org/10.5735/085.052.0202

Boissier E, Reuter G (1842) Diagnoses plantarum novarum Hispanicarum. Typis Ferdinandi Ramboz, Geneva, 1–28. https://bibdigital.rjb.csic.es/en/records/item/9535-diagnoses-plantarum-novarum-hispanicarum

Braun-Blanquet J (1928) Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer, Berlin, 1–888. https://doi.org/10.1007/978-3-662-02056-2

Brullo S, Marcenò C (1985) Contributo alla conoscenza della vegetazione nitrofila della Sicilia. Colloques Phytosociologique 12: 23–148.

Castroviejo S, Pascual H (1998) *Lupinus hispanicus* Boiss. & Reut., s.l. (Leguminosae). Anales del Jardín Botánico de Madrid 56(2): 416–418.

Castroviejo S, Pascual H (2000) *Lupinus* L. In: Castroviejo S (Ed.) Flora Ibérica, vol. 7. Real Jardín Botánico–CSIC, Madrid, 251–260.

Cavara F (1904) Note floristiche e fitogeografiche di Sicilia IV–VI. Bullettino della Società Botanica italiana, 358–369. https://www.biodiversitylibrary.org/item/34180

Chamberlain DF (1970) *Lupinus*. In: Davis PH (Ed.) Flora of Turkey and the East Aegean Islands. vol. 3. Edinburgh Univ. Press, Edinburgh, 38–40.

Costa J C, Neto C, Aguiar C, Capelo J, Espírito Santo M D, Honrado J, Pinto-Gomes C, Monteiro-Henriques T, Sequeira M, Lousã M (2012) Syantoxonomical checklist of vascular plants communities in Portugal (Continental, the Azores and Madeira). Global Geobotany 2: 1–180.

Dimopoulos P, Raus Th, Bergmeier E, Constantinidis T, Iatroú G, Kokkini S, Strid A, Tzanoudakis D (2013) Vascular Plants of Greece. An annotated checklist. Englera 31: 1–372.

Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. http://www.europlusmed.org [accessed 09/05/2024]

Flora spontanea Siciliana (2024) Flora spontanea Siciliana. https//www.facebook.com/groups/floraspontaneasiciliana/ [accessed on 20 May 2024].

Galasso G, Conti F, Peruzzi L, Alessandrini A, Ardenghi NMG, Bacchetta G, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Castello M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Guarino R, Gubellini L, Guiggi A, Hofmann N, Iberite M, Jiménez-Mejías P, Longo D, Marchetti D, Martini F, Masin RR, Medagli P, Musarella CM, Peccenini S, Podda L, Prosser F, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2024) A second update to the checklist of the vascular flora alien to Italy. Plant Biosystems 158(2): 297–340. https://doi.org/10.1080/11263504.2024.2320129

Gandoger MM (1901) Notes Sur La Flore Espagnole. Bulletin de la Société botanique de France 48: 405–418. https://doi.org/10.1080/00378941.1901.10831860

GBIF (2024) Global Biodiversity Information Facility. https://www.gbif.org/ [accessed on 20 May 2024]

Giardina G, Raimondo FM, Spadaro V (2007) A catalogue of plants growing in Sicily. Bocconea 20: 5–582.

Gladstones JS (1974) Lupins of the Mediterranean region and Africa. Technical bulletin (Western Australia. Department of Agriculture) 26: 1–47. https://catalogue.nla.gov.au/catalog/2959847

Hayek A (1927) Prodromus Florae Peninsulae Balcanicae. Repertorium specierum novarum regni vegetabilis / Beihefte 30(1): 1–1193. https://www.zobodat.at/pdf/MON-B-PHAN_0427_0001-1193.pdf

Heyn CC, Herrnstadt I (1977) Seed coat structure of Old World *Lupinus* species. Botaniska Notiser 130(4): 427–435. https://eurekamag.com/research/006/378/006378197.php

Lema M, Soengas P (2023) Identification of promising accessions of wild *Lupinus hispanicus* Boiss. et Reut. from northwestern Spain. Genetic Resources and Crop Evolution 70: 677–690. https://doi.org/10.1007/s10722-022-01531-2

Lojacono Pojero M (1891) Flora Sicula, 1(2). Forni Editore, Palermo,1–376.

Mahé F, Pascual H, Coriton O, Huteau V, Navarro Perris A, Misset MT, Aïnouche A (2011) New data and phylogenetic placement of the enigmatic Old World lupin: *Lupinus mariae-josephi* H. Pascual. Genetic Resources and Crop Evolution 58: 101–114. https://doi.org/10.1007/s10722-010-9580-6

Marzouk RI (2006) Taxonomic consequences of seed morphology and anatomy in three *Lupinus* species (Fabaceae-Genisteae). Catrina 1(2): 1–8.

Merino B (1905) Flora descriptiva e ilustrada de Galicia. Tipografía Galaica, Santiago. https://doi.org/10.5962/bhl.title.10911

Milla R, Escudero A, Iriondo JM (2011) Congruence between geographic range distribution and local competitive ability of two *Lupinus* species. American Journal of Botany 98(9): 1456–1464. https://doi.org/10.3732/ajb.1000519

Mucina L, Bültmann H, Dierßen K, Theurillat JP, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, Gavilán García R, Chytrý M, Hájek M, Di Pietro R, Iakushenko D, Pallas J, Daniëls FJA, Bergmeier E, Santos Guerra A, Ermakov N, Valachovič M, Schaminée JHJ, Lysenko T, Didukh YP, Pignatti S, Rodwell JS, Capelo J, Weber HE, Solomeshch A, Dimopoulos P, Aguiar C, Hennekens SM, Tichý L (2016) Vegetation of Europe: Hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Vegetation Science 19(S1): 3–264. https://doi.org/10.1111/avsc.12257

Musmeci G (2024) Natura Dell'Etna – La Vegetazione. Stampa Ligure, Genova.

Naganowska B, Ladoň D (2000) Chromosomes of *Lupinus hispanicus* subsp. *hispanicus* Boiss.et Reut., *L. luteus* L. and their hybrids. Journal of Applied Genetics 41(3): 167–170. https://bibliotekanauki.pl/articles/2043412.pdf

Pignatti S, Guarino R, La Rosa M (2017) Flora d'Italia 2, Ed. 2. Edagricole, Bologna.

POWO (2024) Plants of the World Online. http://www.plantsoftheworldonline.org/ [accessed 10.05.2024]

R Core Team (2022) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Rafinesque-Schmaltz CS (1815) Chloris Aetnensis o le Quattro Florule dell'Etna. In: Recupero G (Ed.) Storia naturale e generale dell'Etna. Stamperia della Regia Università degli Studi, Catania, 1–15.

Raimondo F, Domina G, Spadaro V (2010) Checklist of the vascular flora of Sicily. Quaderni di Botanica Ambientale e Applicata 21: 189–252.

Sciandrello S, Minissale P, Giusso del Galdo G (2020) Vascular plant species diversity of Mt. Etna (Sicily): endemicity, insularity and spatial patterns along the altitudinal gradient of the highest active volcano in Europe. PeerJ 8: e9875. https://doi.org/10.7717/peerj.9875

Stoyanov S, Apostolova-Stoyanova N (2022) *Lupinus gredensis* (Fabaceae), a new non-native species to Bulgaria and the European part of Turkey. Phytologia Balcanica 28(2): 231–237. https://doi.org/10.7546/PhB.28.2.2022.7

Strid A (2016) Atlas of the Aegean Flora. Botanischer Garten und Botanisches Museum Berlin-Dahlem and Freie Universität, Berlin, 1–1578.

Strid A (2024) Atlas of the Hellenic Flora, vol. 1. Broken Hill Publishers Ltd, 1–2132.

Strobl G (1880) Flora des Aetna. Oesterreichische botanische Zeitschrift 30: 363–371. https://doi.org/10.1007/BF01634542

Thiers B [Ed.] (2024) [Continuously updated] Index herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/ [Accessed 09 May 2024]

Tornabene F (1889–1892) Flora Aetnea. Tipografia Galati, Catania, 1–676.